PUTTING RESEARCH TO WORK **BRIEF**

# Fabrication Concerns in High-Mast Luminaire and Sign Supports

In 1998, a 40-foot luminaire support mast collapsed onto I-894 in West Allis. In recent years, other luminaire supports have collapsed in Milwaukee and Eau Claire, and a full-span sign support in Eau Claire exhibited excessive vibration and nearly collapsed. The sign support was removed in February 1997, only six months after it was put into service.

After the I-894 luminaire support collapse, the Wisconsin Department of Transportation examined almost 500 luminaire support masts in the Milwaukee area. This research showed that salt spray can corrode the masts, reducing wall thickness near the base by 20%. Forensic analysis of the Eau Claire sign support span found extensive cracking in its diagonal supports, and cracks in the truss that were present when it was galvanized. Welded truss structures throughout the state have shown similar cracking.

## What's the Problem?

Structures like the sign support in Eau Claire and the luminaire supports in Milwaukee have performed poorly across the country. Experts have attributed cracking of the structures to fatigue and loading due to truck-induced gusts, natural wind, and aeroelastic phenomena, and most recent national research has focused on improving performance through revised loading considerations. The resultant conservative loading and fatigue requirements have complicated and lengthened design procedures.

However, the investigation of the Eau Claire sign support linked its problems not to design, but to fabrication. Current conservative, loading-centered design provisions may not prevent structural failures such as those experienced in Wisconsin.

## Research Objectives and Methodology

Researchers sought to improve the design of full-span sign support structures and high-mast luminaire structures, and to determine reasonable inspection intervals for these structures. Their tasks included:

- Simulation and modeling of wind and truck-induced gust pressures.
- Generating fatigue-life predictions for sign and luminaire support structures to identify fatigue-critical details and to compare the predictions to the service lives of poorly performing structures. This helped quantify the role of fabrication in leading to shortened service life.
- Evaluating three full-span sign support structures, studying their vibration characteristics and their susceptibility to aerodynamic instabilities and to damage from truck-induced pressure pulses.
- Evaluating two high-mast luminaire support structures, studying the impact of baseplate thickness and baseplate anchor rod stand-off height on their susceptibility to vibrations. Researchers also analyzed stress in the base and stress distribution in mast walls.

## Results

The evaluation of full-span sign support structures found:

- Aeroelastic phenomena (e.g., vortex-shedding and galloping) do not need special consideration in design specifications. Truck-induced gusts only warrant design consideration for spans longer than 100 feet.
- Sign supports built with tri-chord trusses are more susceptible to twisting deformations caused by wind, and are likely to have service lives shorter than the 50-year target; four-chord trusses are preferable. Four-chord structures with grouted bases should be favored over those with anchor rod stand-offs, as bending stresses dramatically shorten the fatigue lives of exposed anchor rods.
- All sign support structures should be inspected during fabrication and immediately after erection. Researchers recommend further inspection at five-year intervals through 10 years for four-chord

**Investigator**

*"If we insist on well-fabricated high-mast luminaire support structures that are installed according to specifications, their fatigue lives will easily exceed the 50-year target."*

**–Christopher Foley**
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This high-mast luminaire support in Menomonee Falls, left, contains the recommended eight-bolt anchor structure and 1.5-inch-thick baseplate, and is in excellent condition after over 10 years of service (Fig. 3.71a, page 166 of final report). At right, the anchor rod stand-off in this sign support structure in Waukesha County increases the bending stresses in the anchor rods, resulting in fatigue sensitivity (Fig. 3.16, page 79).

structures with anchor rod stand-offs, and through 15 years for tri-chord structures, at which point inspections should become biannual. Four-chord, fixed-based structures should be inspected at 10-year intervals for 40 years, and then biannually.

The evaluation of high-mast luminaire supports found:

• Anchor rod stand-off height has little impact on vibration frequency. Baseplate thickness is a more important factor; baseplates should be at least 1.5 inches thick.

• Four-bolt anchor rod configurations proved more susceptible to stress concentrations in the mast wall, and these configurations led to greater bending stresses in the anchor rods. Researchers recommend that four-bolt anchor rod configurations not be used in high-mast luminaire support structures.

• If inspected during fabrication and immediately after erection, luminaire supports may not require subsequent inspections during their 50-year service life.

## Implementation and Benefits

With proper fabrication and installation, both types of sign and luminaire support structures studied can easily last 50 years or more. By eliminating truck-induced pressures and aeroelastic phenomena from design considerations for these structures, WisDOT can shorten and simplify the design process.

Adopting the inspection intervals recommended in this research will reduce WisDOT's inspection costs for sign and luminaire supports. By requiring detailed inspection of all structures during fabrication and immediately after erection, WisDOT can replace its current two-year inspection cycles with five- or 10-year cycles for sign supports, and even longer cycles for luminaire supports.

## Further Research

The interaction of galvanization with welded connections during fabrication, and its link to poor structure performance, urgently requires research. In addition, the study of anchor rod bending in baseplates with stand-off heights, and of statistical variability in the fatigue lives of sign and luminaire support structure components, would enrich our understanding of service failures and successes.

**Project Manager**

***"By focusing on the details of the supports that are fatigue-prone, we can improve our design criteria."***

**–Stan Woods**
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*Nina McLawhorn, Research Administrator*